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An image of P- to S-wave velocity ratios in the forearc of the Central Andean subduction zone

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The ratio of seismic P- to S-wave velocities (the Vp/Vs ratio) of a given rock volume is a sensitive proxy for the detection of fluids and melts. In subduction regimes it has often been inferred from seismic tomography and been used, e.g., to detect pathways of ascending melt above the seismogenic zone, where tomographic methods have their highest resolution. We present Vp/Vs ratios that were computed using only seismic arrival time observations following the approach of Lin and Shearer (2007). This approach has its highest sensitivity in the source volume of a set of nearby seismic events and is hence particularly well suited to directly probe the plate interface.

We present data from a temporary local network of short period seismometers that was in operation in the forearc of the Central Andean subduction zone at 21° S between 2005 and 2012. From this database we were able to localize 3253 seismic events (Ml ∼0.5–4) with high precision, yielding a detailed image of the seismicity distribution in this region. Seismicity is pervasive within the entire crust of the South American continental plate and exhibits three distinct bands in the subducting slab, the lowermost one being located in the lithospheric mantle of the subducting plate. The highest concentration of seismic events is found in the contact zone between the continental and the oceanic lithosphere at depths between 30 and 50 km.

We group seismic events into approximately 100 subsets of nearby events that origin from the same geological structure. For about half of these subsets we are able to extract a reliable local Vp/Vs ratio. In the middle continental crust, Vp/Vs ratios show slightly enhanced values (∼1.75). In the lower continental crust towards the plate interface they tend to increase from this value updip and decrease downdip. At the plate interface itself, we observe higher Vp/Vs ratios (>1.8) at shallower depths (between 20 and 40 km). Downdip (40–60 km depth) Vp/Vs ratios decrease to rather typical values (∼1.75). The same trend is observed in the lowermost band of mantle seismicity in the subducting slab. Below 80 km depth, where mineral transitions toward the eclogite facies are expected to occur, Vp/Vs ratios tend to be low (<1.75).

The consistently high Vp/Vs ratios in the shallow part of the subducting slab hint at the presence of fluids in the porespace of the subducting lithosphere there. In the deeper part, downdip variations of Vp/Vs may be attributed to mineral phase transitions due to the changing P-T-conditions along the subduction pathway.